What Is It and Where Did It Come From?
A Study of Particulate Flow Patterns into Baltimore MD, July 2011

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Background

Aerosols are tiny particles of solids, liquids, or gases which become temporarily suspended in the air for varying lengths of time. Many particles are caused by natural means, but a significant portion of aerosols, especially the smaller ones, are anthropogenic: caused by Man.

PM2.5 are aerosols with diameters less than 2.5μm. Most anthropogenic aerosols are classified as PM2.5. Due to their small size, they can remain in the air for days, weeks or even months giving them increased opportunity to react with other substances in the atmosphere often with deleterious effect.

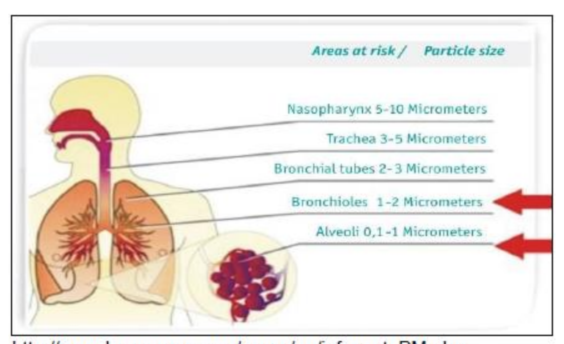
In the atmosphere, aerosols can:

- Affect visibility
- Form cloud condensation nuclei
- React with other particles forming hazardous compounds
- Scatter or absorb and then re-emit energy from photons
- Contribute to radiative forcing, a change in the radiation budget of the planet in which humans play a significant role.

The size of aerosols can indicate their source, potential behaviors in the atmosphere, and their affects on human health.

In the biosphere aerosols can:

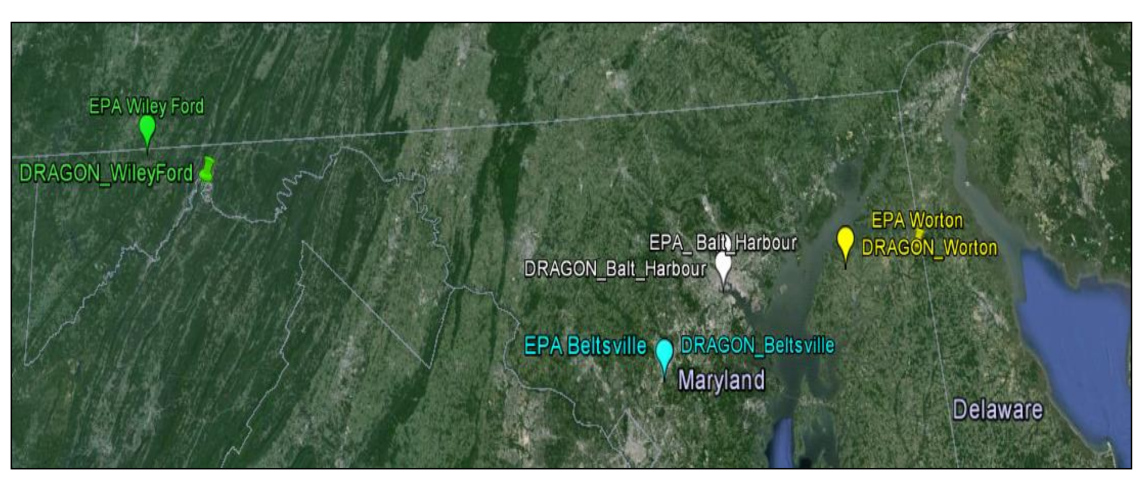
- Interfere with the processes of plant respiration and photosynthesis
- Contribute to cardiovascular disease
- Result in irregular heartbeat
- Lead to aggravated asthma
- Decrease lung function
- Irritate the airways
- Make breathing difficult



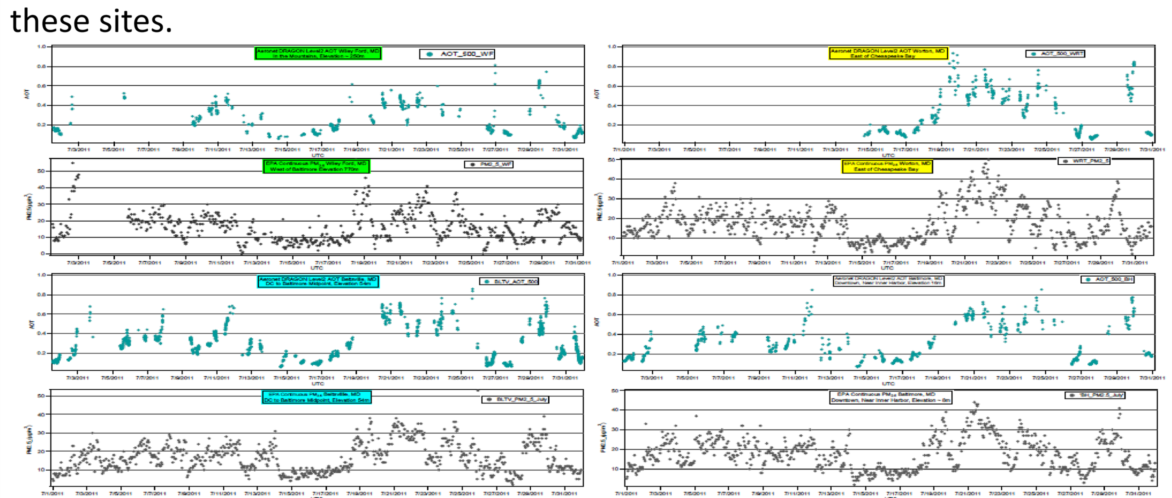
http://www.hussgroup.com/group/en/infocentePM.php

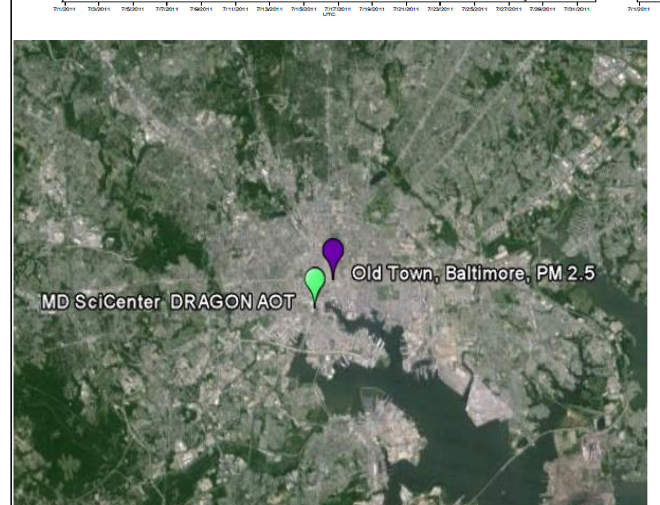
First year focus was on measurement methods and instrumentation used in the study of aerosolized particulate matter in the atmosphere.

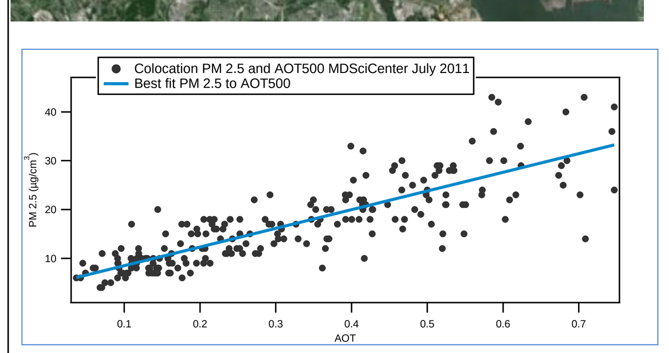
Four sites across Maryland in the Aeronet **DRAGON** (Distributed Regional Aerosol Gridded Observation Network) and DISCOVER-AQ Summer 2011 mission were used.



Two plots for each site: AOT on top, and PM 2.5 on bottom. Plots are similar in shape, suggesting a correlation between PM2.5 and AOT 500nm for these sites.



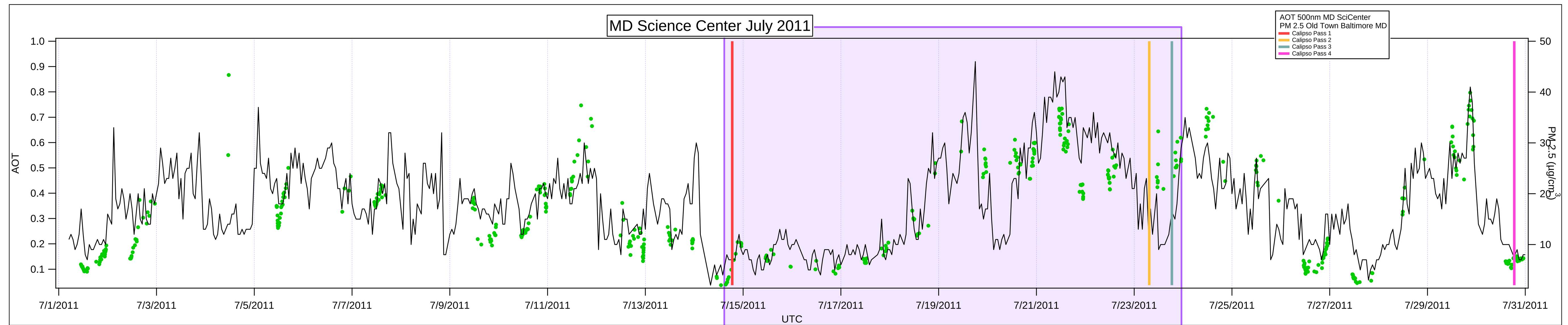


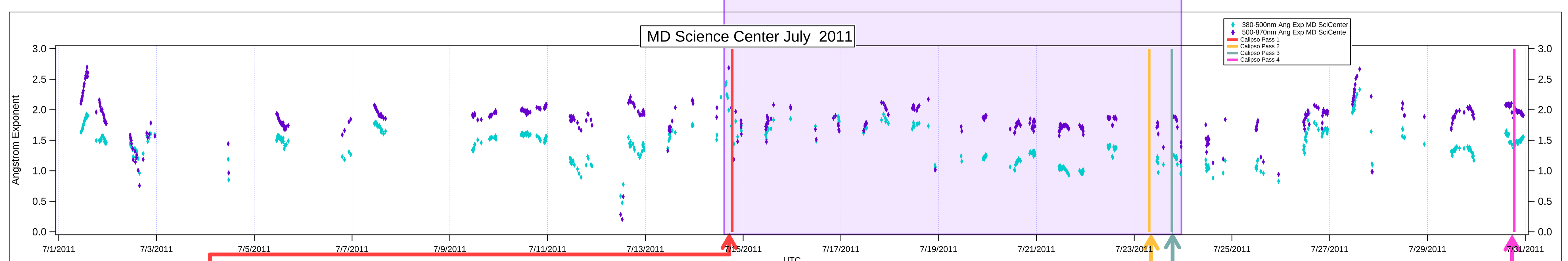


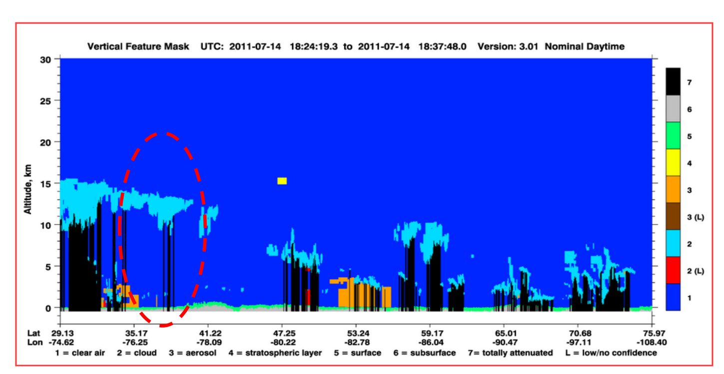
Second Year Focus:

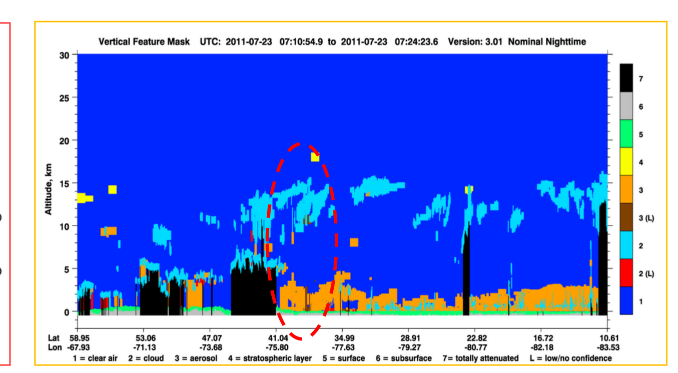
MD Science Center near Old Town Baltimore and the Inner Harbor.

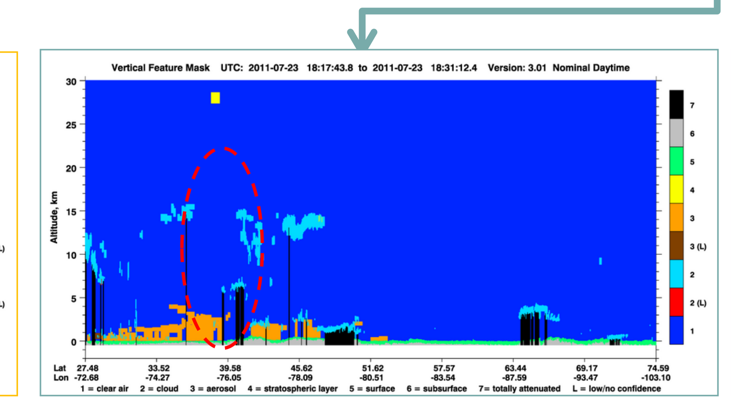
This graph (below left) demonstrates a strong correlation between PM 2.5 and AOT. The trends in the relationship between these measurements and long and short wavelength Angstrom Exponent values are explored to understand what is in the air at this location, where it came from, and how it got there.

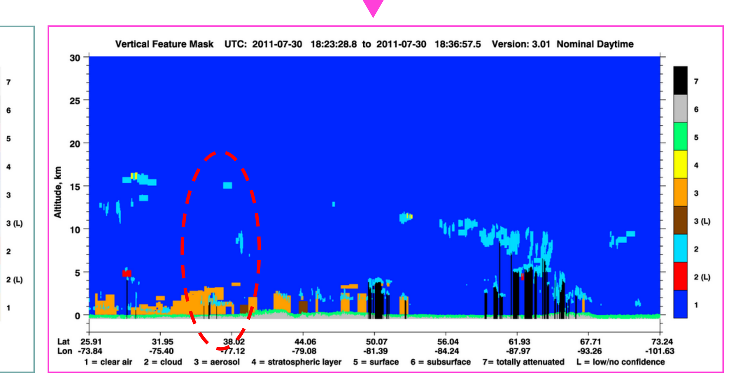


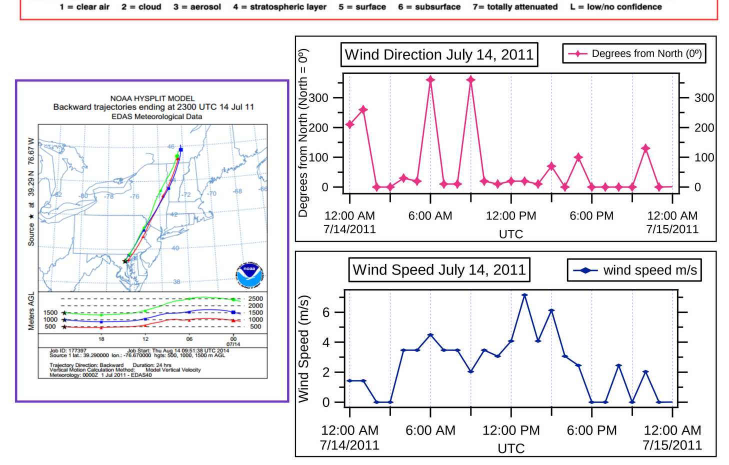


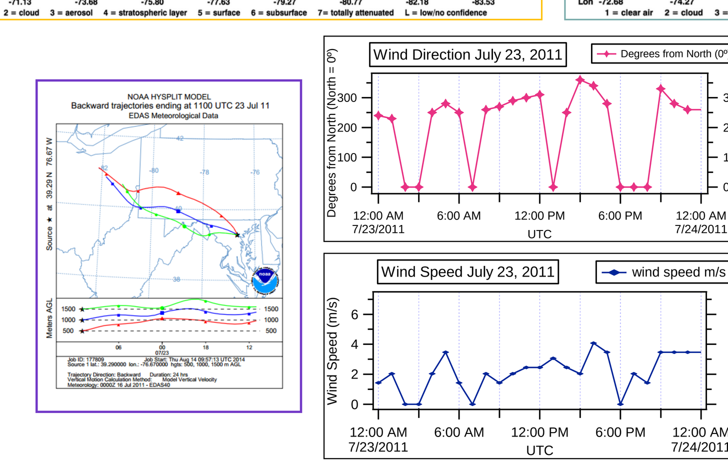


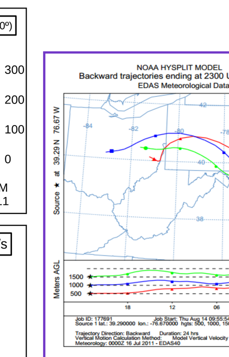


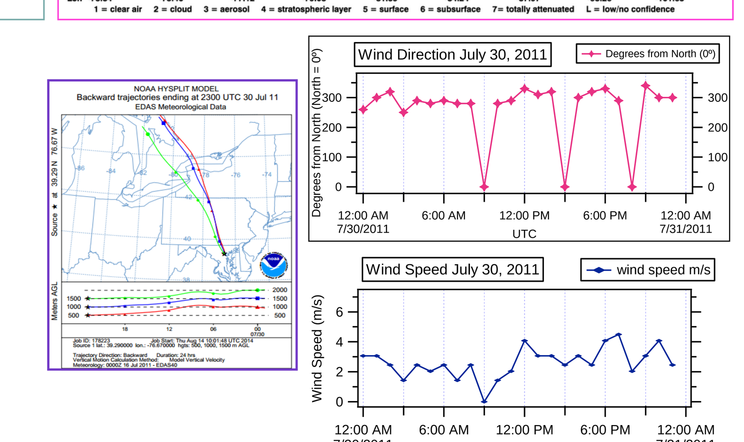




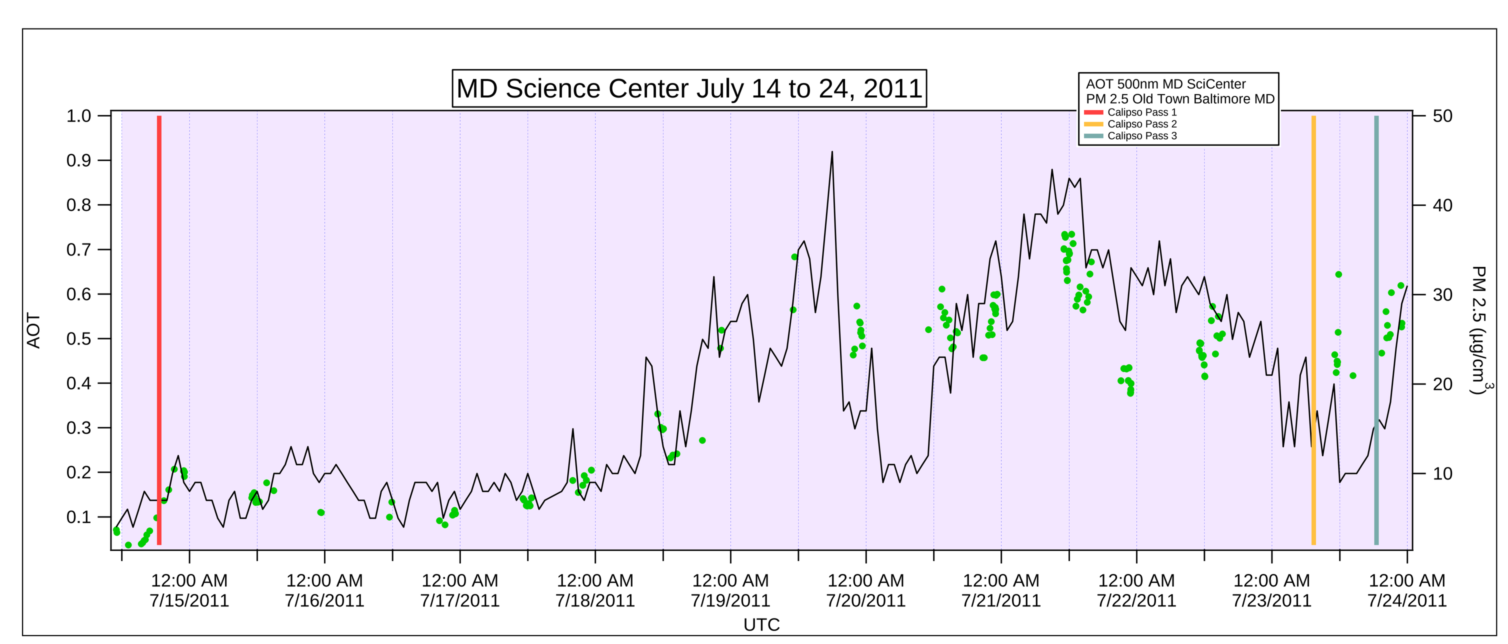


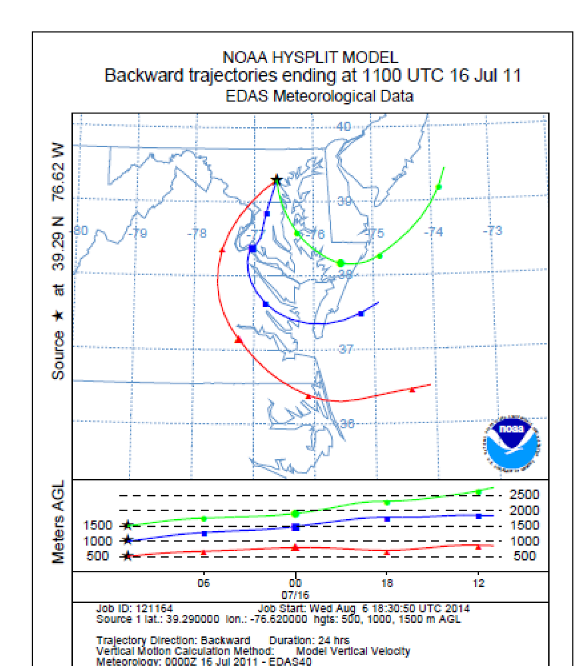


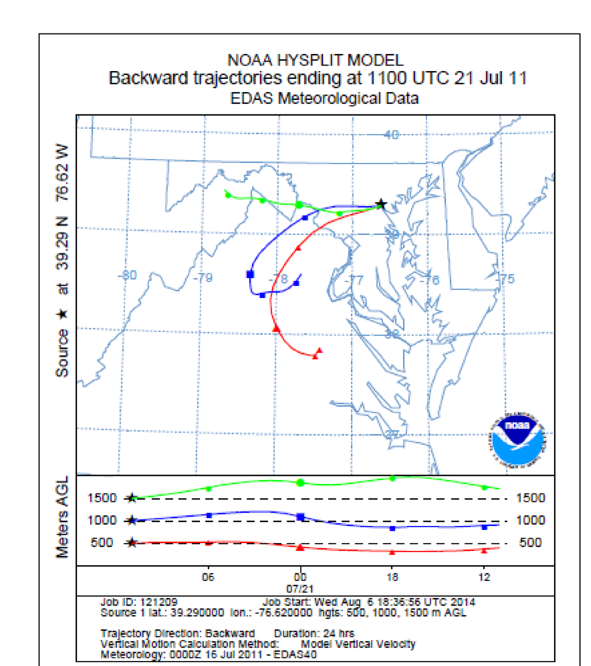


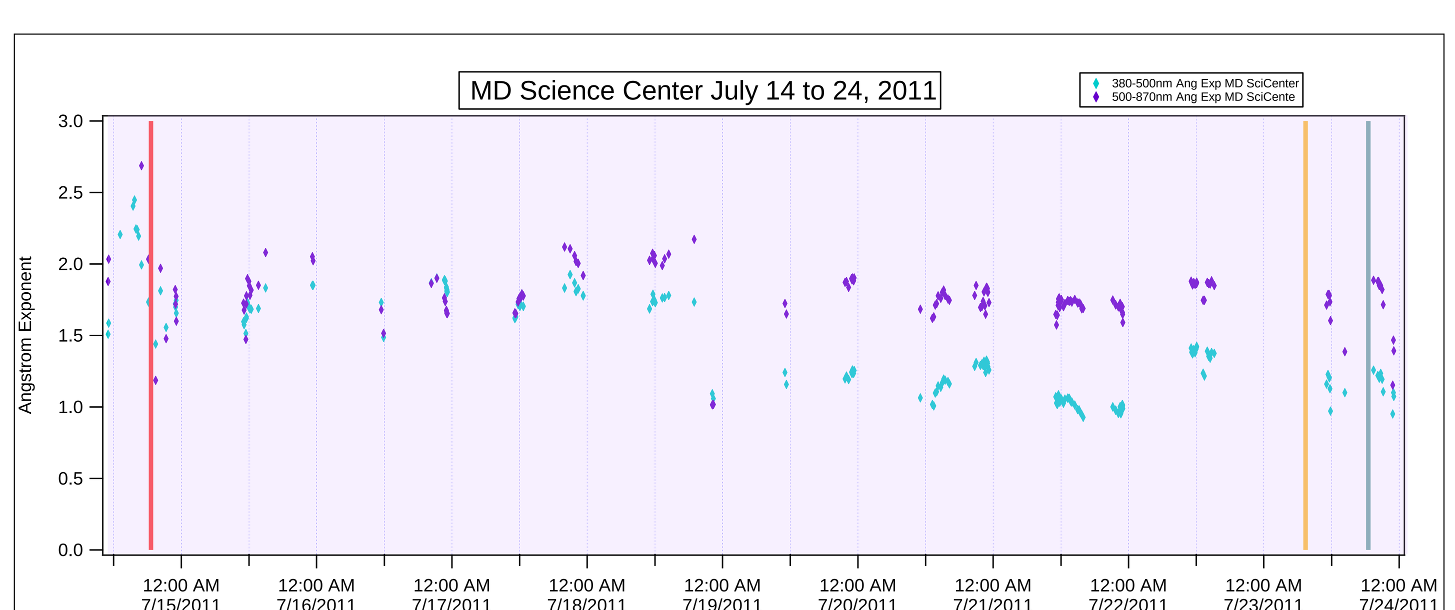


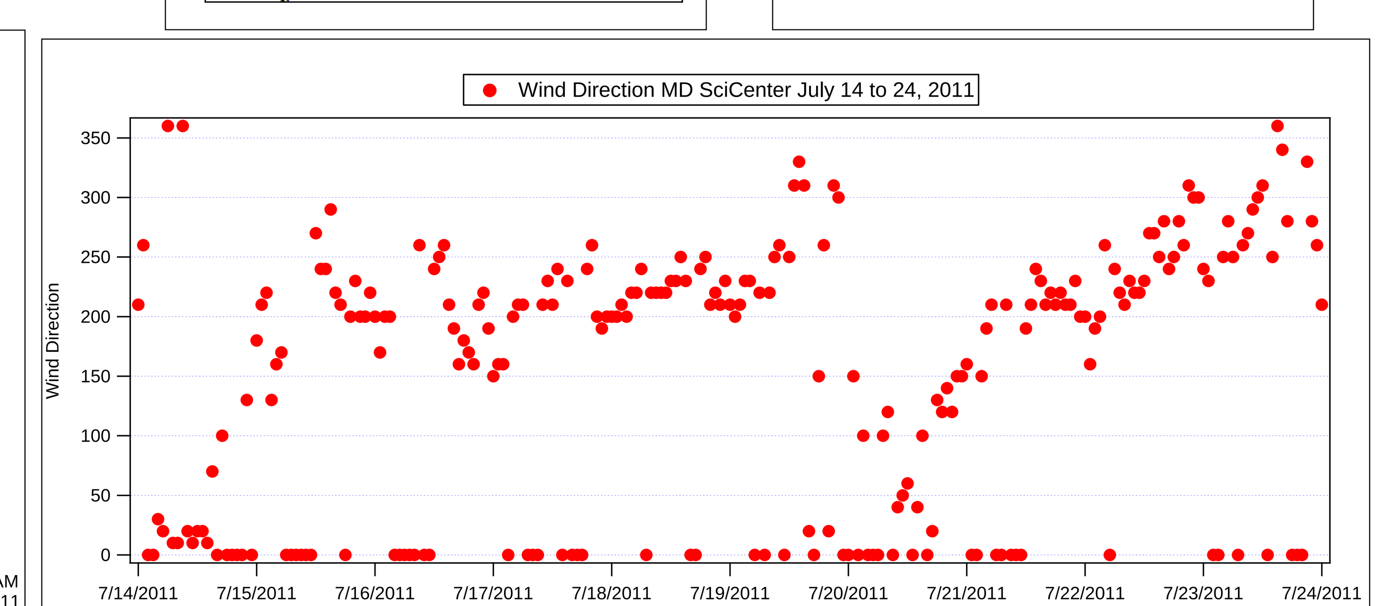
Case Study











Angstrom Exponent

The Angstrom Exponent, α, is a wavelength dependent term found using the expression below:

$$\alpha = -\frac{\ln(\tau_{\lambda_1}/\tau_{\lambda_2})}{\ln(\lambda_1/\lambda_2)}$$

Where τ represents AOT at wavelengths λ_1 and λ_2.
α can be used indicate the effective radius and fine mode fraction of aerosols in a given region of the atmosphere.

As particles increase in size, α will decrease, so, where 1≤α≤3, particles have a greater chance of being anthropogenic.

Further, the relationship between wavelength and α indicates that for longer wavelengths, λ < 500nm, values of are linked to greater fine mode volume fraction, whereas shorter wavelengths, λ < 500nm, values of are linked to fine mode effective radius.

Discussion

The strong correlation between AOT and PM 2.5 indicates a relatively even distribution of aerosols in the atmosphere above the site. Further inspection shows a fluctuation in the amount and type of aerosols throughout the month. There are periods of "cleaner" air with lower levels of PM 2.5 and AOT, followed by periods of "dirtier" air, when PM 2.5 and AOT levels increase.

The long wavelength Angstrom Exponent values for the case study period remain close to 2, indicating a relatively constant and high fine mode fraction, the ratio of smaller to larger particles in a given volume of air. However, the short wavelength Angstrom Exponent values during this time show fluctuation. This indicates that there is a change in the effective radius of the aerosols present.

July 16: "Cleaner air" day.
Values of PM 2.5 and AOT are low. Short wavelength Angstrom Exponent values are close to 2 indicating aerosols present have a larger effective radius, meaning they are more than likely of natural origin.

Backscatter plots for this day show the source is out of the east, from the ocean, with sea salt particulate, with larger effective radii, being consistent with the cleaner air and observed short wavelength values of Angstrom Exponent.

July 21: "Dirtier air" day.
Values of PM 2.5 and AOT are higher. Short wavelength Angstrom Exponent values are closer to 1 indicating aerosols present have a smaller effective radius, meaning they are more likely of anthropogenic origin.

Backscatter plots for this day show the source is out of the west, over land, with anthropogenic particulate, with smaller effective radii, being consistent with the observed long wavelength values of Angstrom Exponent.

Acknowledgements

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Citations

Schuster, G. , O. Dubovnik, and B. Holben *The Angstrom Exponent and Bimodal Aerosol Size Distribution, (2009).* Journal of Geophysical Research DOI:10.1029